VERIFICATION OF TRANSLATION

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declare that I am well acquainted with both the Japanese and English languages, and that the attached is a literal translation, to the best of my knowledge and ability, of

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[Title of the Invention] Stack type battery and related method

[Scope of Claims for Patent]

[Claim 1] A stack type battery comprising:

a plurality of unit cells stacked by the unit cells in series, wherein a shared voltage measurement tab electrode for measuring a voltage of each unit cell is provided in each of said unit cells; and a voltage measurement tab electrode is arranged at another position than that of at least an adjacent voltage measurement tab electrode.

[Claim 2] The stack type battery according to claim 1, wherein said shared voltage measurement tab electrodes are arranged deviating sequentially from each other at a same interval in the longer direction of a side surface of the battery.

[Claim 3] The stack type battery according to claim 2, wherein said shared voltage measurement tab electrodes arranged deviating sequentially from each other at a same interval in a longer direction of said side surface of the battery, are arranged in a plurality of rows.

[Claim 4] The stack type battery according to any one of claims 1 to 3, wherein said shared voltage measurement tab electrodes are arranged on the both opposing side surfaces of the battery.

[Claim 5] The stack type battery according to any one of claims 1 to 4, wherein by connecting said shared voltage measurement tab electrodes to each other, said unit cells of a plurality of said stack type batteries are connected to each other in parallel.

[Claim 6] The stack type battery according to any one of claims 1 to 5, comprising:

a bipolar electrode produced by stacking a positive electrode active material layer, a current collector and a negative electrode active material layer in this order; and

a polymer solid electrolyte layer,

wherein at least one of said positive electrode active material layer and negative electrode active material layer comprises a polymer solid electrolyte.

[Claim 7] The stack type battery according to claim 6, which is a lithium ion secondary battery.

[Claim 8] The stack type battery according to claim 6 or 7, wherein a negative electrode active material comprised in said negative electrode active material layer is an oxide of a metal or a compound oxide comprising a metal and lithium.

[Claim 9] The stack type battery according to claim 6 or 7, wherein a negative electrode active material comprised in said negative electrode active material layer is carbon.

[Claim 10] The stack type battery according to claim 9, wherein said carbon is a hard carbon.

[Claim 11] The stack type battery according to any one of claims 1 to 10, wherein to said shared voltage measurement tab electrode, a socket having a shared voltage tab electrode for connecting a unit cell controller controlling a charging voltage of said unit cell to said shared voltage measurement tab electrode, is connected.

[Claim 12] The stack type battery according to claim 10, wherein said unit cell controller is produced integrally with said socket.

[Claim 13] The stack type battery according to claim 6, wherein said unit cell controller is a current bypass circuit for connecting electrically said positive electrode and negative electrode to each other when a voltage of said unit cell exceeds a prescribed value.

[Claim 14] The stack type battery according to claim 13, wherein said current bypass circuit comprises a Zener diode connected between said positive electrode and negative electrode of said unit cell.

[Claim 15] The stack type battery according to claim 13, wherein said current bypass circuit comprises a series circuit in which a Zener diode connected between said positive electrode and negative electrode of said unit cell, and a resistor are connected to each other in series.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a stack type battery.

[0002]

[Prior Art]

Recently, reduction in emission of carbon dioxide for

environmental protection is earnestly desired. In an automobile field, reduction in emission of carbon dioxide through introduction of electric vehicles (EV) and hybrid electric vehicles (HEV) has been highly expected, and research and development work has been diligently done to provide a motor driving secondary battery that has a key to be put into a practical use. As the secondary battery, the spotlight of attention is focused upon a lithium battery (lithium ion battery) that can achieve a high energy density and high power output density.

[0003]

In particular, in order for the secondary battery to ensure a high power output to be applied to an automobile, there has been a proposal to provide a stack type battery comprised of a plurality of secondary batteries (each battery being hereinafter referred to as a unit cell) that are connected in series.

[0004]

It is preferred for the stack type battery to idealistically allow respective unit cells to share voltages to provide a ratio of (charging voltage) / (the number of unit cells connected in series).

[0005]

However, in actual practice, variation occurs in internal resistance and capacity for the unit cell and, therefore, fluctuation takes place in the voltages shared by the respective unit cells. As a result, deterioration proceeds from the unit cell whose shared voltage is high and it is conceivable that a life cycle of the stack type battery tends to be limited by the unit cell having such a high shared voltage.

[0006]

To cope with such a phenomenon, it is preferred to construct to compel the voltages shared by respective unit cells to be controlled so as to allow all the unit cells to uniformly share the voltages.

[0007]

To this end, there is a need for preparing electrodes for measuring the voltages of the unit cells one by one.

[0008]

Japanese Patent Application Laid-Open Publication No. 2001-250741 is related to a capacitor that differs from a battery in a

technical field but discloses a structure wherein, in a stack type electric double layer capacitor composed of a plurality of stack capacitors, shared voltage measurement tab electrodes are formed on each of the plurality of capacitors for measuring shared voltages.

[0009]

[Problem to Be Solved by the Invention]

However, there is a large difference in electrode component material, charging and discharging mechanism and capacity between the capacitor and the battery and, so, it is hard to simply apply a technology of the capacitor to the battery.

[0010]

With respect to the battery constructed of a plurality of unit cells, since a distance between the electrodes for each unit cell is extremely short and a short distance results in between adjacent shared voltage measurement tab electrodes, there is a danger of occurrence of mutual contact or mutual conduct. Particularly, in case of the secondary battery, since an electric power is continuously derived through chemical reaction and, if such a situation occurs by any chance, the battery tends to continuously provide the power output differing from short-circuiting of the capacitor, there is such a fear that not only the short-circuited portion but also the battery as a whole are destroyed.

[0011]

In order to avoid this fear, although it is considerable for one surface of the shared voltage measurement tab electrode to be stacked with a contact preventive insulation film, only the shared voltage measurement tab electrode portion becomes thick and a disadvantage is caused wherein sealing property and space efficiency are lowered, so that the above-noted countermeasure cannot be employed.

[0012]

Further, in the case where the shared voltage measurement tab electrodes are provided, another disadvantage is caused wherein when placing the voltage measurement socket or the unit cell controller onto the shared voltage measurement tab electrodes, a distance between the tabs is too small with a resultant tendency in occurrence of a complicated wiring structure in the voltage measurement socket or the

unit cell controller.

[0013]

Therefore, an object of the present invention is to provide a stack type battery in which a voltage of each unit cell can be measured.

[0014]

[Means to Solve the Problems]

To achieve such an object, according to one aspect of the present invention, there is provided a stack type battery which comprises: a plurality of unit cells stacked in a stack direction to be connected in series; and shared voltage measurement tab electrodes formed on the plurality of unit cells, respectively, to allow voltages to be measured for the plurality of unit cells such that at least two adjacent shared voltage measurement tab electrodes are disposed at deviated positions.

[0015]

Further, in another aspect of the present invention, the stack type battery comprises: a bipolar electrode produced by stacking a positive electrode active material layer, a current collector, and a negative electrode active material layer in this order; and a polymer solid electrolyte layer, wherein at least one of the positive electrode active material layer and the negative electrode active material layer comprises the polymer solid electrolyte layer.

[0016]

Further, in still another aspect of the present invention, to the shared voltage measurement tab electrode, a socket having a shared voltage tab connecting electrode for connecting an unit cell controller controlling a charging voltage of the unit cell to the shared voltage measurement tab electrode, is connected.

[0017]

[Effect of the Invention]

According to a stack type cell of the present invention, there is not such a danger that shared voltage measurement tab electrodes are contacted with each other and a short-circuit is caused, so that a shared voltage of each unit cell becomes able to be easily measured.

[0018]

[Mode for carrying out the Invention]

Hereinafter, a mode for carrying out the present invention is described with referring to the drawings.

[0019]

Fig. 1 is a perspective view showing a constitution appearance of a battery according to the present invention, and Fig. 2 is a side view of the battery as viewed in a direction as shown by an arrow A in Fig. 1.

[0020]

This battery is produced by connecting a plurality of unit cells connected in series and by stacking them. The structure of the battery is shown by a bipolar battery 1 comprising: a bipolar electrode produced by stacking a positive electrode active material layer, a current collector, and a negative electrode active material layer in this order; and a polymer solid electrolyte layer disposed between the bipolar electrode.

[0021]

Then, as shown in Fig. 2, connected to current collectors of respective unit cells that form the bipolar battery 1 are shared voltage measurement tab electrodes 10 to 17 to allow voltages of the unit cells to be measured, respectively.

[0022]

The shared voltage measurement tab electrodes 10 to 17 are so arranged to avoid at least adjacent tab electrodes from laying on the same horizontal position. More particularly, the shared voltage measurement tab electrodes 10 to 17 are arranged from a side surface of the bipolar battery 1 in a longer direction of the battery 1 deviating sequentially from each other at a same interval in a height direction of the battery 1. The number of shared voltage measurement tab electrodes may be suitably determined depending upon the number of stack unit cells.

[0023]

Further, to the current collectors arranged at both ends of the bipolar battery 1 main circuit tab electrodes 19 and 20 are connected.

[0024]

Fig. 3 is a schematic view illustrating an internal structure of the bipolar battery 1.

[0025]

The bipolar battery 1 is produced by stacking alternately n pieces of a bipolar electrode 30 produced by disposing a positive electrode current collector layer 32 and a negative electrode active material layer 33 respectively on the both sides of a current collector 31, and n+1 pieces of a polymer solid electrolyte layer 40; and by stacking electrodes 21 and 22 of the battery respectively on the both outermost polymer solid electrolyte layers 41. The electrodes 21 and 22 of the cell are connected to an external circuit respectively through the main circuit tab electrodes 19 and 20 attached respectively to the both outermost current collectors 31.

[0026]

A positive electrode (+) terminal side electrode 21 is produced by disposing only a positive electrode active material layer 32 on the current collector 31. On the contrary, a negative electrode (-) terminal side electrode 22 is produced by disposing only a negative electrode active material layer 33 on the current collector 31.

[0027]

The number of the stacks of the bipolar electrodes 30 may be adjusted depending upon a desired voltage output. When an adequate output can be secured even when the thickness of the sheet-shaped cell is made extremely thinner, it may be possible to decrease the number of the stacks of the bipolar electrodes. Also, in the figure, although n is selected to be typically 7, of course, the present invention is not limited to such a numeral.

[0028]

During the use of the bipolar battery 1, for preventing an external impact to the bipolar battery 1 and an environmental degradation due to the bipolar battery, it is preferred that a battery stacked in a sheet-shape is accommodated in a battery case 45. The battery case 45 is preferably produced, for example by coating an inner surface of aluminum, stainless steel, nickel or copper with an insulation material, such as a polypropylene film.

[0029]

The bipolar battery 1 is used in a lithium ion secondary battery that achieves charging and discharging through transfer of lithium ions.

However, when it is possible to obtain advantageous effects, such as an improvement of battery characteristics, it is not objectionable for the bipolar battery to be applied to batteries of other types.

[0030]

Hereinafter, a structure of the bipolar battery 1 is further described.

[0031]

[Bipolar Electrode]

Fig. 4 is a view illustrating a structure of one bipolar electrode.

[0032]

The bipolar electrode 30 has a structure in which the positive electrode active material layer 32 is disposed on one surface of the integrated current collector 31 and the negative electrode active material layer 33 is disposed on another surface of the current collector 31, that is, in the structure, the positive electrode active material layer 32, the current collector 31 and the negative electrode active material layer 33 are stacked in this order.

[0033]

In contrast to such a bipolar electrode 30, in a battery comprising general electrodes, when the unit cells are connected in series, a positive electrode current collector and a negative electrode current collector are electrically connected to each other through a connecting portion (such as a wiring). With respect to such a battery, connecting resistance is generated in the connecting portion, which leads to a lowering of the power output. Also, in view of miniaturization of a battery module, it is disadvantageous that a member which does not directly contribute to the electric power generating occupies a space, which leads to a lowering of the energy density of the whole battery module.

[0034]

The bipolar electrode can solve such a problem. In other words, the connecting portion which connects electrodes which are connected in series, to each other is not present, so that a lowering of the output due to the resistance of the connecting portion is not caused and further, the miniaturization of the battery module can be intended. Further, according to the absence of the connecting portion, the energy density of

the whole battery module can be improved.

[0035]

In the bipolar battery 1, at least one of the positive electrode active material layer 32 and the negative electrode active material layer 33 comprises a polymer solid electrolyte.

Thus, by filling a void between active materials in an active material layer with a polymer solid electrolyte, an ion transfer in the active material layer becomes smooth and an improvement of a power output of the whole bipolar battery can be intended.

[0036]

[Current Collector]

Fig. 5 is a view illustrating structures of each current collector 31 used in a bipolar electrode of a battery according to the first mode for carrying out.

[0037]

As shown in figures, in the current collectors 111, 112, 113 and 117, the voltage measurement tab electrodes 11 to 17 are respectively provided in different positions from that of each other. And in the current collectors 111 and 117 which serve respectively as the positive electrode (+) terminal side electrode 21 and the negative (-) terminal side electrode 22, the main circuit tab electrodes 19 and 20 are provided respectively on different sides of a rectangle of the current collector from a side of a rectangle of the current collector on which the shared voltage measurement tab electrodes 11 to 17 are provided. Since the current collectors having the shared voltage measurement tab electrodes 14 to 16 are structurally similar to the above-noted current collectors except only that the positions in which the shared voltage measurement tab electrodes 14 to 16 are provided, differ from those in which the shared voltage measurement tab electrodes 11 to 13 and 17, showing the current collectors 114 to 116 in figures has been omitted.

[0038]

By stacking the bipolar electrodes constituted using such current collectors 110 to 117, as shown in Figs. 1 and 2, the positions of the shared voltage measurement tab electrodes 11 to 17 can be prevented from being overlapped onto each other because of being deviated from

each other in a longer direction of the side surface of the bipolar battery 1.

[0039]

Accordingly, even when the unit cell is thin, it can be prevented that the shared voltage measurement tab electrodes 11 to 17 are contacted with each other and a short-circuit is caused. Further, since by the positional arrangement of the shared voltage measurement tab electrodes 11 to 17, such a problem that these electrodes are contacted with each other has been already solved, there is no need for sticking an insulation film onto one surface of the shared voltage measurement tab electrodes 11 to 17. Therefore, the battery becomes not thicker, even when the shared voltage measurement tab electrodes 11 to 17 are provided.

[0040]

[Positive Electrode Active Material Layer]

The positive electrode active material layer 32 comprises a positive electrode active material and a polymer solid electrolyte. In addition to them, the layer 32 can comprise a lithium salt or a conductant auxiliary for enhancing the ion conductivity of the layer 32.

[0041]

As the positive electrode material, a compound oxide comprising a transition metal and lithium which is employed in a lithium ion battery of a solution type can be used. Specific examples of the compound oxide include Li-Co compound oxide, such as $LiCoO_2$; Li-Ni compound oxide, such as $LiNiO_2$; Li-Mn compound oxide, such as spinel type $LiMn_2O_4$; and LI-Fe compound oxide, such as $LiFeO_2$. Besides them, specific examples of the positive electrode material include a phosphate compound or sulfate compound of a transition metal and lithium, such as $LiFePO_4$; an oxide or sulfide of a transition metal, such as V_2O_5, MnO_2, TiS_2, MoS_2 and MoO_3; PbO_2; AgO; and NiOOH.

[0042]

The positive electrode active material may preferably have a particle diameter less than a generally-used particle diameter of a positive electrode active material used in a lithium ion battery of a solution type in which the electrolyte is not solid, for lowering the

electrode resistance of the bipolar battery. Specifically, the positive electrode active material has preferably an average particle diameter of from 0.1 to 5 μm.

[0043]

The polymer solid electrolyte is not particularly limited so long as it is a polymer having an ion conductivity. Examples of a polymer having an ion conductivity include a polyethylene oxide (PEO), a polypropylene oxide (PPO) and copolymer of thereof. Such a polyalkylene oxide polymer can satisfactorily dissolve a lithium salt, such as $LiBF_4$, $LIPF_6$, $LiN(SO_2CF_3)_2$ and $LiN(SO_2C_2F_5)_2$. Also, by forming cross-linkage structure, an excellent mechanical strength is expressed. According to the present invention, at least one of the positive electrode active material layer and the negative electrode active material layer comprises the polymer solid electrolyte. However, for improving battery properties of a bipolar battery, it is preferred that the both comprise the polymer solid electrolyte.

[0044]

Examples of the lithium salt include $LiBF_4$, $LiPF_6$, $LiN(SO_2CF_3)_2$, $LiN(SO_2C_2F_5)_2$, and a mixture thereof. However, the lithium salt is not limited to these compounds.

[0045]

Examples of the conductant auxiliary include an acetylene black, a carbon black and a graphite. However, the conductant auxiliary is not limited to these compounds.

[0046]

Amounts of the positive electrode active material, the polymer solid electrolyte, the lithium salt and the conductant auxiliary in the positive electrode active material layer should be determined on consideration of application purposes of the battery (with a serious consideration in power output, energy, or the like). For example, when the amount of the polymer solid electrolyte in the active material layer is too small, an ionic conduction resistance and an ionic diffusion resistance become larger, so that a battery performance is lowered. On the contrary, when the amount of the polymer solid electrolyte in the active material layer is too large, an energy density of the battery is

lowered. Accordingly, in consideration of these factors, the amount of polymer solid electrolyte should be appropriately determined so as to comply with intended purposes.

[0047]

Here, the case where a bipolar battery in which a priority is given to the battery reactivity is produced using a polymer solid electrolyte (with ion conductivity: 10^{-5} to 10^{-4} S/cm) according to a prior art, is taken into consideration. For obtaining a bipolar battery having such characteristics, an electronic conduction resistance between particles of the active material is maintained relatively low by increasing the amount of the conductant auxiliary or by decreasing the bulk density of the active material. At the same time, a void part is enlarged and the void part is filled with the polymer solid electrolyte. It is preferred that by such a countermeasure, the amount ratio of the polymer solid electrolyte is enhanced.

[0048]

The thickness of the positive electrode active material layer is not particularly limited and as previously described with respect to the amount of the components, the thickness of the positive electrode active material layer should be also determined in consideration of the application purposes of the battery (with a serious consideration in power output, energy, or the like) and the ion conductivity. The positive electrode active material layer has generally about 10 to 500 μm.

[0049]

[Negative Electrode Active Material Layer]

The negative electrode active material layer 33 comprises a negative electrode active material and a polymer solid electrolyte. Besides them, a lithium ion salt and a conductant auxiliary may be also comprised therein. Except the type of the negative electrode active material, the content of the part of [Negative Electrode Active Material Layer] is satisfactorily the same as the content described in the part of [Positive Electrode Active Material].

[0050]

As the negative electrode active material, although it is possible to

use negative electrode active materials that are used in the lithium ion battery of the solution type, in particular a polymer solid electrolyte is preferred; however, in consideration of the reactivity of the polymer solid electrolyte to be comprised, metal oxides or compound oxides comprising a metal and lithium are preferred. More preferably, the negative electrode active material is oxides of transition metals or compound oxides comprising transition metals and lithium. Still more preferably, the negative electrode active material is a titan oxide or compound oxides comprising titan and lithium.

[0051]

Further, as the negative electrode active material, in addition to the above compounds, carbon is also preferred. When carbon is used as the negative electrode active material, by introducing a lithium ion into lithium, the same high voltage battery as a battery produced using a negative electrode active material comprising lithium can be obtained. As a carbon to be used, a hard carbon is preferred. Since a hard carbon causes the bipolar battery to have a larger voltage fluctuation according to a fluctuation in a charged state in comparison with a graphite, the voltage fluctuation allows the charged state to be predicted. Accordingly, it is needless to provide effort or a device for calculating a charged state from amounts of output input electricity, and a charging control of the unit cell and a device therefor becomes simple.

[0052]

[Polymer Solid Electrolyte Layer]

The polymer solid electrolyte layer 40 is a layer comprising a polymer having an ion conductivity and the material thereof is not particularly limited so long as the material exhibits an ion conductivity. Examples of the polymer solid electrolyte include known polymer solid electrolytes, such as a polyethylene oxide (PEO), a polypropylene oxide (PPO) and a copolymer thereof. Further, the polymer solid electrolyte layer 40 comprises lithium salts for securing the ion conductivity. Examples of lithium salts include $LiBF_4$, $LiPF_6$, $LiN(SO_2CF_3)_2$, $LiN(SO_2C_2F_5)_2$ and a mixture thereof. However, the lithium salts are not limited to these compounds. A polyalkylene oxide polymer, such as PEO and PPO can satisfactorily dissolve lithium salts, such as $LiBF_4$,

$LIPF_6$, $LiN(SO_2CF_3)_2$ and $LiN(SO_2C_2F_5)_2$. Also, by forming a cross-linkage structure, an excellent mechanical strength is expressed.

[0053]

Although a polymer solid electrolyte may be comprised in the polymer solid electrolyte layer, the positive electrode active material layer and the negative electrode active material layer. The types of the polymer solid electrolyte comprised in these layers may be the same or different from each other.

[0054]

The thickness of the polymer solid electrolyte layer is not particularly limited. However, for obtaining a compact bipolar battery, it is preferred that the thickness of the polymer solid electrolyte layer is as extremely small as possible so long as the function as the electrolyte layer can be secured. The polymer solid electrolyte layer has generally a thickness of about 5 to 200 μm.

[0055]

A polymer for the polymer solid electrolyte which is currently and preferably used is a polyether polymer, such as PEO and PPO. Therefore, a positive electrode side of the battery has a less oxidation resistance under a high temperature condition. Consequently, when a positive electrode agent having a high oxidation-reduction potential which is generally used in a lithium ion battery of a solution type is used, it is preferred that the capacity of the negative electrode is less than that of the positive electrode which opposes to the negative electrode via the polymer solid electrolyte layer. When the capacity of the negative electrode is less than that of the opposing positive electrode, a positive electrode potential can be prevented from excessively increasing at the end of charging. Here, "the positive electrode opposing via the polymer solid electrolyte layer" designates a positive electrode which is a constituting element in the same unit cell. The capacities of the positive electrode and the negative electrode can be obtained as theoretical capacities during manufacturing the positive electrode and the negative electrode based on a manufacturing condition. It is also satisfactory to directly measure the capacity of a completed product by a measurement device.

[0056]

However, when the capacity of the negative electrode is less than that of the opposing positive electrode, the negative electrode potential is excessively lowered and the durability of the battery might be impaired, so that there is a need for paying attention to a charging and discharging voltage. For example, by setting an average charging voltage of one unit cell to an appropriate value corresponding to the oxidation-reduction potential of a positive electrode active material to be used, attention will be paid to preventing the lowering of the durability.

[0057]

As described above, since the bipolar battery 1 according to the first mode for carrying out of the present invention has the shared voltage measurement tab electrodes 11 to 17 which are provided respectively on one side of each current collector of a unit cell deviating sequentially from each other in the longer direction of the side surface of the bipolar battery 1 so that these electrodes are not overlapped when the current collectors are stacked, the shared voltages of each unit cell can be easily measured. Moreover, since the shared voltage measurement tab electrodes 11 to 17 are provided deviating sequentially from each other in the longer direction of the side surface of the bipolar battery 1 so that these electrodes are not overlapped at the same position when the current collectors are stacked, even when the thickness of the unit cell becomes less, it is possible to avoid such a disadvantage that the adjacent shared voltage measurement tab electrodes are contacted with each other and a short circuit is caused. Also, this results in no need for coating one surface of the shared voltage measurement tab electrode with an insulation coating, thereby enabling making the thickness of the unit cell thinner.

[0058]

Further, since the shared voltage measurement tab electrodes 11 to 17 are lined up at the same interval in the longer direction of the side surface of the bipolar battery 1, a structure of a voltage measurement socket connected to the shared voltage measurement tab electrodes 11 to 17 can be simple and the manufacturing thereof becomes easier.

[0059]

In addition, since the bipolar battery 1 according to the present first mode for carrying out uses a polymer solid electrolyte as an electrolyte, a liquid communication between the cells can be prevented without providing specific members. Also, since the bipolar battery comprises a polymer solid electrolyte in an active material layer, the inside of the active material layer is excellent in ion conductivity and the bipolar battery has high battery properties.

[0060]

Moreover, when the bipolar battery 1 uses a hard carbon as a negative electrode material, the charging control of the unit cell can be easily performed only by measuring the voltage. By using a hard carbon, a charged state of the unit cell can be detected by measuring the voltage of the unit cell, so that the battery can be produced as a stack type battery with a simplified structure and high power output.

(Second Mode for carrying out)

Fig. 6 is a perspective view showing an external structure of a battery according to the second mode for carrying out of the present invention, and Fig. 7 is a side view of the battery as viewed in a direction shown by the arrow A in Fig. 6.

[0061]

A battery according to the second mode for carrying out is the bipolar battery 2 which is similar to a battery according to the above-noted first mode for carrying out. In the present second mode for carrying out, as shown in Fig. 7, the shared voltage measurement tab electrodes 211 to 217 and 221 to 227 are disposed in two rows in such a manner that they are provided respectively on one side of each current collector of a bipolar battery 2 deviating sequentially from each other at the same interval in the longer direction of the side surface of the bipolar battery 2 so that these electrodes are not overlapped when the current collectors are stacked. The number of shared voltage measurement tab electrodes varies depending on the number of stack unit cells. Since the inner structure of the battery is the same as that of the battery according to the first mode for carrying out described referring to Fig. 3, the description thereof will be omitted. Like the first mode for carrying out, to the current collectors positioned on the both terminals of

the bipolar battery 2, main circuit tab electrodes 19 and 20 are attached.

[0062]

Fig. 8 is a plan view showing each current collector according to the present second mode for carrying out. As shown in Fig. 8, in the present second mode for carrying out fundamentally similar to the first mode for carrying out, in each of current collectors 231, 232, 237 and 247, the shared voltage measurement tab electrodes 211 to 217 and 221 to 227 are provided in different positions, respectively. In the current collectors 231 and 247 which serve respectively as the positive electrode (+) terminal side electrode 21 and the negative (-) terminal side electrode 22, the main circuit tab electrodes 19 and 20 are provided respectively on different sides of a rectangle of the current collector from a side of a rectangle of the current collector on which the shared voltage measurement tab electrodes are provided.

[0063]

And, according to the present second mode for carrying out, in a current collector 217 positioned in the center point of the stack unit cells structure, at the both terminals on one side of a rectangular of the current collector 217, respectively shared voltage measurement tab electrodes 217 and 221 are provided. Accordingly, the distance between the voltage measurement tab electrodes (for example, between a pair of electrodes for measuring a shared voltage, such as between 216 and 217 or 221 and 222) can be maintained constant. Therefore, it is satisfactory with a simple structure of a socket for measuring a voltage corresponding to the shared voltage measurement tab electrodes 211 to 217 and 221 to 227.

[0064]

Since the current collectors having the shared voltage measurement tab electrodes 214 to 216 and 221 to 226 are structurally similar to the above-noted current collectors except only that the positions in which the shared voltage measurement tab electrodes 214 to 216 and 221 to 226 are provided, differ from those in which the shared voltage measurement tab electrodes 211 to 213 and 217, and 221 to 223 and 227, showing the current collectors 214 to 216 and 221 to 226 in figures has been omitted.

[0065]

Thus, in the present second mode for carrying out, by providing in two rows the shared voltage measurement tab electrodes which are arranged at the same interval in the longer direction of the battery side surface while preventing overlapping on each other in the stack condition, when the number of stack unit cells is large, it can be prevented that the shared voltage measurement tab electrodes of adjacent unit cells are contacted with each other and a short-circuit is caused. Further, among the shared voltage measurement tab electrodes arranged in two rows, the shared voltage measurement tab electrodes in a current collector positioned in the center point of the stack unit cells structure are provided at the both terminals on one side of the rectangular of the current collector, so that the distance between the voltage measurement tab electrodes is constant and it is satisfactory with a simple structure of a socket for measuring the voltage.

[0066]

(Third Mode for carrying out)

Fig. 9 is a perspective view showing an external structure of a battery according to the third mode for carrying out of the present invention. Fig. 10 (a) is a side view of the battery as viewed in a direction shown by an arrow A in Fig. 9 and Fig. 10B is a side view of the battery as viewed in a direction shown by an arrow B in Fig. 9.

[0067]

This battery is the bipolar battery 3 which is similar to a battery according to the above-noted first mode for carrying out. In the present third mode for carrying out, as shown in Fig., the shared voltage measurement tab electrodes 311 to 317 and 321 to 327 are disposed on the both side surfaces opposing to each other of the bipolar battery 3 in such a manner that they are provided respectively on one side of each current collector of the bipolar battery 3 deviating sequentially from each other at the same interval in the longer direction of the side surface of the bipolar battery 3 so that they are not overlapped when the current collectors are stacked. The number of shared voltage measurement tab electrodes varies depending on the number of stack unit cells. Since the inner structure of the battery is the same as that of the battery according to the first mode for carrying out described referring to Fig. 3,

the description thereof will be omitted. Like the first mode for carrying out, to the current collectors positioned on the both terminals of the bipolar battery 3, main circuit tab electrodes 19 and 20 are attached.

[0068]

The shared voltage measurement tab electrodes 311 to 317 and 321 to 327 provided on the both side surfaces opposing to each other of the bipolar battery 3 project alternately to the right and to the left according to the stack order of the unit cells.

[0069]

More specifically, as shown in Figs. 9 and 10, a shared voltage measurement tab electrode 311 provided in a first unit cell stacked as a first uppermost layer of the battery project to the side shown by the arrow A in Fig. 9. A shared voltage measurement tab electrode 321 provided in a second unit cell stacked as a second uppermost layer of the battery project to the side shown by the arrow B in Fig. 9, and a shared voltage measurement tab electrode 312 provided in a third unit cell stacked as a third uppermost layer of the battery project to the side shown by the arrow A in Fig. 9. Further, such a projection of the electrode is repeated alternately to the right and to the left.

[0070]

Fig. 11 is a plan view showing each current collector according to the present third mode for carrying out. As shown in Fig. 11, in each current collector according to the present third mode for carrying out, a shared voltage measurement tab electrode is provided so that the shared voltage measurement tab electrodes project alternately to the right and to the left according to the stack order when the unit cells are stacked. More specifically, in a current collector 331 of a first unit cell, a shared voltage measurement tab electrode 311 projects to the right in Fig. 11, in a current collector 342 of a first unit cell, a shared voltage measurement tab electrode 321 projects to the left in Fig. 11, in a current collector 332 of a first unit cell, a shared voltage measurement tab electrode 312 projects to the right in Fig. 11, and in the same manner, the shared voltage measurement tab electrodes project alternately to the right and to the left. At the last, in the last current collector 347, a shared voltage measurement tab electrode 327 projects to the left in Fig. 11. In the

current collectors 331 and 347 which serve respectively as the positive electrode (+) terminal side electrode 21 and the negative (-) terminal side electrode 22, the main circuit tab electrodes 19 and 20 are provided respectively on different sides of a rectangle of the current collector from a side of a rectangle of the current collector on which the shared voltage measurement tab electrodes are provided.

[0071]

Since the current collectors having the shared voltage measurement tab electrodes 313 to 317 and 322 to 326 are structurally similar to the above-noted current collectors except only that the positions in which the shared voltage measurement tab electrodes 313 to 317 and 322 to 326 are provided, differ from those in which the shared voltage measurement tab electrodes 311, 312 and 327, showing the current collectors 333 to 337 and 342 to 346 in figures has been omitted.

[0072]

Thus, in the present third mode for carrying out, by providing on the both sides of the battery the shared voltage measurement tab electrodes 311 to 317 and 321 to 327 which are arranged at the same interval in the longer direction of the battery side surface while preventing overlapping on each other in the stack condition, when the number of stack unit cells is large, it can be prevented that the shared voltage measurement tab electrodes of adjacent unit cells are contacted with each other and a short-circuit is caused. Particularly in the present third mode for carrying out, since the shared voltage measurement tab electrodes in the adjacent current collectors project alternately to a side of the battery and to another side of the battery, it can be more reliably prevented that the shared voltage measurement tab electrodes in the adjacent current collectors are contacted with each other and a short-circuit is caused.

[0073]

(Fourth Mode for carrying out)

Fig. 12 is a perspective view showing an external structure of a battery according to the fourth mode for carrying out of the present invention.

[0074]

In the fourth mode for carrying out, the bipolar battery is produced by attaching an unit cell controller unit 400 to the bipolar battery 1 according to the above-noted first mode for carrying out.

[0075]

As shown in Fig. 13, the unit cell controller unit 400 is produced integrally with a socket provided with shared voltage tab connection electrodes 401 to 407 corresponding to the shared voltage measurement tab electrodes 11 to 17 provided in the bipolar battery 1. Fig. 13 is a view of a socket part of the unit cell controller unit 400 from the side of the shared voltage tab connection electrodes 401 to 407.

[0076]

The unit cell controller unit 400 is a current bypass circuit which bypasses an electrolyte present between each positive electrode and each negative electrodes of a plurality of unit cells by connecting the positive electrode and the negative electrode when a voltage of the unit cell exceeds a prescribed value.

[0077]

Fig. 14 is a circuit diagram showing an example of the above-noted current bypass circuit.

[0078]

This current bypass circuit 50 is a circuit produced by connecting a Zener diode 52 and a resistor 54 in series between the positive electrode (+) and the negative electrode (-) of a unit cell 55. When the Zener voltage of the Zener diode 52 is exceeded, the current bypass circuit 50 bypasses a current during the charging.

[0079]

Fig. 15 is a circuit diagram showing a structure in which the current bypass circuits 50 are connected in the unit cell controller unit 400.

[0080]

In the unit cell controller unit 400, the current bypass circuits 50 comprising one set of Zener diode 52 and the resistor 54 are provided between the shared voltage connection tab electrodes 401 and 402, 402 and 40, 403 and 404, 404 and 405, 405 and 406, and 406 and 407, respectively. The showing of the current bypass circuits 500 between

the shared voltage tab connection electrodes 404 and 405, and 405 and 406 has been omitted.

[0081]

Then, by connecting the unit cell controller unit 400 to the bipolar battery 1, the current bypass circuits 50 are connected in parallel to each unit cell of the bipolar battery 1. And during charging the bipolar battery 1, the Zener diode 52 is connected to the unit cell 55 in a direction to block conduction of the Zener diode 52 with respect to a direction in which current is applied to the unit cell 55. At an initial stage in which charging is started, since a charging voltage of the unit cell 55 constituting the bipolar battery 1 does not reach the Zener voltage (a voltage at which Zener diode 52 of the current bypass circuit 50 conducts), almost no current flows through the current bypass circuit 50.

[0082]

As charging proceeds, a voltage across terminals of the unit cells is increased and when such a voltage exceeds the Zener voltage, the Zener diode 52 of the current bypass circuit 50 conducts to bypass a current flowing through the unit cell 55. For example, when using the Zener diode 52 whose Zener voltage is 4.0 volts, the charging of the unit cell 55 is terminated when the voltage across the terminals becomes 4.0 volts.

[0083]

The unit cell 55 whose voltage across the terminals reaches the charging voltage automatically terminates the charging thereof and when all the current bypass circuits 50 has bypassed the unit cells 55, the charging of the bipolar battery 1 is terminated. Under a condition in which all the unit cells 55 have been bypassed, an electric current supplied by a charger flows through the current bypass circuits 50 which are connected in series, however, this electric current is limited by the resistors 54 connected to the Zener diodes 52 in series. Consequently, the resistors 54 have a function to suppress an increase of an electric current which flows through the current bypass circuits 50 when the current bypass circuits 50 bypasses an electric current, for preventing an excessive electric current through the current bypass circuits 50. A

value of the resistance of the resistor 54 is selected to a value by which an excessively large electric current are prevented from flowing through the current bypass circuit 50.

[0084]

As described above, in the present fourth mode for carrying out, by connecting the unit cell controller unit 400 produced integrally with the socket on which the shared voltage tab connection terminals 401 to 407 corresponding to the shared voltage measurement tab electrodes 11 to 17 provided in the bipolar battery 1, are provided, the charging voltage of each unit cell of the bipolar battery 1 can be easily controlled.

[0085]

Further, since by providing the current bypass circuits 50 in the unit cell controller unit 400, the current bypass circuit is actuated to terminate the charging when the charging voltage of the unit cell exceeds the prescribed value, it is possible to prepare a uniform and optimum charging environment even when the battery properties, such as a battery capacity and an internal resistance are nonuniform. Therefore, no biased charged condition occurs in each unit cell and uniform charging can be achieved, so that the life and the reliability of the battery is improved. Thus, by providing the current bypass circuit for a purpose of preventing an overcharging of the unit cell, the charging state of each unit cell can be made even in a full charged state and it can be prevented that some unit cells enters into an overcharged state due to a dispersion of the charged state.

[0086]

In the present fourth mode for carrying out, although the current bypass circuit 50 comprises the Zener diode 52 and the resistor 54 which are connected in series, the current bypass circuit 50 may comprise only the Zener diode. However, when the current bypass circuits 50 bypasses a current, a charging current of the bipolar lithium ion secondary battery increases, it is preferred that the current bypass circuit 50 comprises rather the resistor 54 which can suppress to an extent an increase of the electric current flowing through the current bypass circuit 50 for preventing a flow of an excessive current through the current bypass circuits 50.

[0087]

(Fifth Mode for carrying out)

Fig. 16 is a perspective view showing an external structure of a battery according to the fifth mode for carrying out of the present invention.

[0088]

In the fifth mode for carrying out, the bipolar battery is produced by attaching an unit cell controller unit 500 to the bipolar battery 2 according to the above-noted second mode for carrying out.

[0089]

In a unit cell controller unit 500 according to the present fifth mode for carrying out, like the unit cell controller unit produced integrally with the socket according to the above-noted fourth mode for carrying out, as shown in Fig. 17, the shared voltage tab connection electrodes 501 to 507 and 511 to 517 corresponding to the shared voltage measurement tab electrodes 211 to 217 and 221 to 227 of the bipolar battery 2 are disposed in two rows. Like in the above-noted fourth mode for carrying out, in the inside of the unit cell controller unit 500, a current bypass circuit comprising a Zener diode and a resistance is provided.

[0090]

Therefore, in the bipolar battery 2 according to the second mode for carrying out, the charging voltage of each unit cell can be easily controlled like in the bipolar battery 1.

[0091]

(Sixth Mode for carrying out)

Fig. 18 is a perspective view showing an external structure of a battery according to the sixth mode for carrying out of the present invention.

[0092]

In the sixth mode for carrying out, the bipolar battery according to the above-noted third mode for carrying out is connected to the shared voltage tab connection sockets 600 and 610 for connecting the bipolar battery 3 to a unit cell controller.

[0093]

In the shared voltage tab connection sockets 600 and 610, as shown in Fig. 19, there are provided the shared voltage tab connection electrodes 601 to 607 and 611 to 617 corresponding to the shared voltage measurement tab electrodes 311 to 317 and 321 to 327. Fig. 19 (a) is a view of a socket part of the shared voltage tab connection socket 600 viewed from the side of the shared voltage tab connection electrodes 601 to 607, and Fig. 19 (b) is a view of a socket part of the shared voltage tab connection socket 610 viewed from the side of the shared voltage tab connection electrodes 611 to 617.

[0094]

Then, each unit cell in the shared voltage measurement tab electrodes 311 to 317 is connected to each unit cell in the shared voltage measurement tab electrodes 321 and 327 to form a pair of unit cells, respectively. That is, the shared voltage measurement tab electrodes 311 and 321 are connected to each other to form a unit cell, the shared voltage measurement tab electrodes 321 and 312 are connected to each other to form a unit cell, the shared voltage measurement tab electrodes 312 and 322 are connected to each other to form a unit cell, and so forth, so that the voltage of each unit cell formed by connecting a shared voltage measurement tab electrode projecting to a side of the battery to a shared voltage measurement tab electrode projecting to another side of the battery can be measured through each of the shared voltage tab connection electrodes 601 and 611, the shared voltage tab connection electrodes 611 and 602, the shared voltage tab connection electrodes 602 and 612, and so forth.

[0095]

The wirings collected from the shared voltage measurement tab electrodes are connected to a unit cell controller located out of Figs. to measure a voltage of each unit cell, and a charged amount of each unit cell is controlled to be the same.

[0096]

(Seventh Mode for carrying out)

Fig. 20 is a perspective view showing an external structure of a battery according to the seventh mode for carrying out of the present invention.

[0097]

In the seventh mode for carrying out, the battery is produced by connecting a plurality of battery units in which the shared voltage measurement tab electrodes are provided, in parallel through the shared voltage measurement tab electrodes.

[0098]

This battery 700 is produced by connecting a plurality of bipolar battery units 701 which is the same as the bipolar battery according to the above-noted first mode for carrying out in parallel through the respective shared voltage measurement tab electrodes 711 to 717 which are provided in each of the bipolar battery units 701, wherein each unit cell is connected to each other in parallel. Thus, in the internal structure of the battery 700, as shown in Fig. 21, each bipolar electrode 30 in the bipolar battery unit 701 is connected to each other in parallel.

[0099]

Further, a bipolar battery unit 701 located at one end of the bipolar battery 7 has shared voltage measurement tab electrodes 711 to 717 which are not connected to an adjacent bipolar battery unit 701 and to which a unit cell controller unit 400 is connected. The unit cell controller unit 400 is the same as a unit cell controller unit according to the above-noted fourth mode for carrying out.

[0100]

The battery structure in the bipolar battery unit 701 is the same as that of the battery according to the first mode for carrying out described above referring to Fig. 3, and is produced by stacking alternately n pieces of a bipolar electrode 30 in which the positive electrode active material layer 32 and a negative electrode active material layer 33 are respectively disposed on one side of the current collector 31 and n+1 pieces of a polymer solid electrolyte layer 40 and by arranging the electrode of the battery in the outermost polymer solid electrolyte layer 40.

[0101]

As shown in Fig. 22, in each of the current collectors 731 to 737 which will be sequentially stacked to form a bipolar battery unit, each of the shared voltage measurement tab electrodes 711 to 717 is provided on

both opposing sides of the rectangle of the current collector; however, each electrode is provided in a different position on the both sides from that of each other. Consequently, like in the bipolar battery 1 of the above-noted first mode for carrying out (see Fig. 2), the shared voltage measurement tab electrodes 711 to 717 are deviated from each other in a longer direction of the side surface of the bipolar battery unit 701 and are arranged at a same interval for preventing the overlapping of the electrodes in a condition where the current collectors are stacked.

[0102]

Thus, in the present seventh mode for carrying out, by connecting the battery units in which the shared voltage measurement tab electrodes are provided, to each other in parallel through a plurality of the shared voltage measurement tab electrodes 711 to 717, even when a deterioration occurs in any one of the unit cells among the bipolar battery units 701 and an internal resistance has become infinite in a unit cell, the electric current can flow through a unit cell in another bipolar battery unit 701 connected through a shared voltage measurement tab electrode in parallel to a failed unit cell. Therefore, even when a unit cell in any bipolar battery unit 701 is deteriorated, the battery 7 as a hole can be continuously used without causing any rapid degradation in performance.

[0103]

(Eighth Mode for carrying out)

The eighth mode for carrying out is an automobile comprising a stack type battery according to the present invention. More specifically, as shown in Fig. 23, a bipolar battery according to the above-noted first to seventh modes for carrying out, more preferably a bipolar battery equipped with the unit cell controller units according to the fourth to seventh modes for carrying out is installed as a battery module 800 in a floor underneath area of the automobile.

[0104]

The battery module 800 is produced by connecting a plurality of bipolar batteries to each other in series and/or parallel through the main circuit tab electrodes 19 and 20 of the bipolar battery.

[0105]

Such a battery module 800 is used as a driving power supply of the vehicle 801, such as a battery propelled electric vehicle or a hybrid electric vehicle. An installation area of the battery module 800 is not limited to the floor underneath area in the vehicle and the battery module 800 may be located inside an engine room or a ceiling.

[0106]

According to the above-noted modes for carrying out of the present invention, not only a hybrid vehicle and an electric vehicle which are safe and have favorable fuel consumption can be provided, but also less deterioration is caused in each unit cell of the battery and consequently, the life of the battery can be prolonged, so that it becomes possible to extend a battery exchange cycle of the vehicle.

[0107]

Up to here, there has been described the modes for carrying out of the present invention which should not be construed as limiting the scope of the present invention and for example, an appropriate combination of elements in each mode for carrying out can be performed. Further, needless to say, modifications and variations of the present invention can be also performed by those skilled in the art in the scope of the technical concept of the present invention and these modifications and variations are also within the scope of the present invention.

[Brief Description of the Drawings]

[0108]

[Fig. 1]

Fig. 1 is a perspective view showing an external structure of a battery according to the first mode for carrying out of the present invention.

[Fig. 2]

Fig. 2 is a side view of the battery in Fig. 1, as viewed in a direction as shown by an arrow A in Fig. 1.

[Fig. 3]

Fig. 3 is a schematic view for describing an internal structure of a bipolar battery.

[Fig. 4]

Fig. 4 is a view showing a structure of a bipolar battery.

[Fig. 5]

Fig. 5 is a view showing a structure of each current collector according to the first mode for carrying out.

[Fig. 6]

Fig. 6 is a perspective view showing an external structure of a battery according to the second mode for carrying out of the present invention.

[Fig. 7]

Fig. 7 is a side view of the battery in Fig. 6, as viewed in a direction as shown by an arrow A.

[Fig. 8]

Fig. 8 is a showing each current collector according to the second mode for carrying out.

[Fig. 9]

Fig. 9 is a perspective view showing an external structure of a battery according to the third mode for carrying out of the present invention.

[Fig. 10]

Fig. 10 (a) is a side view of the battery in Fig. 9, as viewed in a direction as shown by an arrow A; and Fig. 10 (b) is a side view of the battery in Fig. 9, as viewed in a direction as shown by an arrow B.

[Fig. 11]

Fig. 11 is a view showing each current collector according to the third mode for carrying out.

[Fig. 12]

Fig. 12 is a perspective view showing an external structure of a battery according to the fourth mode for carrying out of the present invention.

[Fig. 13]

Fig. 13 is a view of a socket part of a unit cell controller unit used in the fourth mode for carrying out, as viewed from the side of a shared voltage tab connection electrode.

[Fig. 14]

Fig. 14 is a circuit diagram showing an example of a current bypass circuit.

[Fig. 15]

Fig. 15 is a circuit diagram showing a state in which a current bypass circuit 50 has been provided in a unit cell controller unit.

[Fig. 16]

Fig. 16 is a perspective view showing an external structure of a battery according to the fifth mode for carrying out of the present invention.

[Fig. 17]

Fig. 17 is a view of a socket part of a unit cell controller unit used in the fifth mode for carrying out, as viewed from the side of a shared voltage tab connection electrode.

[Fig. 18]

Fig. 18 is a perspective view showing an external structure of a battery according to the sixth mode for carrying out of the present invention.

[Fig. 19]

Fig. 19 is a view of a shared voltage tab connection socket used in the fifth mode for carrying out, as viewed from the side of a shared voltage tab connection electrode.

[Fig. 20]

Fig. 20 is a perspective view showing an external structure of a battery according to the seventh mode for carrying out of the present invention.

[Fig. 21]

Fig. 21 is a view showing a state in which bipolar electrodes in bipolar battery units have been connected to each other in parallel.

[Fig. 22]

Fig. 22 is a view showing each current collector according to the seventh mode for carrying out.

[Fig. 23]

Fig. 23 is an automobile according to the seventh mode for carrying out of the present invention.

[Legend]

[0109]

1, 2, 3 Bipolar battery

11 to 17, 211 to 217, 311 to 317, 321 to 327	Shared voltage measurement tab electrode
19, 20	Main circuit tab electrode
21	Positive electrode (+) terminal side electrode
22	Negative electrode (-) terminal side electrode
30	Bipolar electrode
31	Current collector
32	Positive electrode active material layer
33	Negative electrode active material layer
40, 41	Polymer solid electrolyte layer
41	Polymer solid electrolyte layer
45	Battery case
50	Current bypass circuit
52	Zener diode
54	Resistor
55	Unit cell
111, 112, 113, 117, 217, 231, 231, 232, 237, 247, 331, 332, 342, 347, 731, 732, 733, 737	Current collector
400, 500	Unit cell controller unit
401 to 407, 501 to 507, 511 to 517, 601 to 607, 611 to 617	Shared voltage tab connection electrode
600, 610	Shared voltage tab connection socket
700	Battery
701	Bipolar battery unit
731	Current collector
800	Battery module
801	Vehicle

[Name of Document] Drawing

[Fig. 1]

[Fig. 2]

[Fig. 3]- terminal, + terminal

[Fig. 4]

[Fig. 5]

[Fig. 6]

[Fig. 7]

[Fig. 8]

[Fig. 9]

[Fig. 10(a)]

[Fig. 10(b)]

[Fig. 11]

[Fig. 12]

[Fig. 13]

[Fig. 14]

[Fig. 15]

[Fig. 16]

[Fig. 17]

[Fig. 18]

[Fig. 19(a)]

[Fig. 19(b)]

[Fig. 20]

[Fig. 21]

[Fig. 22]

[Fig. 23]

[Name of Document] Abstract

[Abstract]

[Problem] To provide a stack type battery in which a voltage of each unit cell can be measured.

[Solution Means] A stack type battery 1 in which in each unit cell, respectively each of shared voltage measurement tab electrodes 11 to 17 for measuring a voltage of each unit cell is provided and the shared voltage measurement tab electrodes 11 to 17 are arranged in such a manner that a shared voltage measurement tab electrode is arranged in another position than that of at least an adjacent shared voltage measurement tab electrode.

[Selected drawing] Fig. 1